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MICROBIOSTRATIGRAPHY AND LITHOSTRATIGRAPHY OF THE UPPER PERMIAN DALAN FORMATION IN KUH-E-SURMEH (ZAGROS BASIN, SOUTHWEST IRAN)

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ABSTRACT

The objective of the present study is to perform Microbiostratigraphy and Lithostratigraphy of the Upper Permian Dalan Formation in Kuh-e-Surmeh (Zagros Basin). The Upper Permian Dalan Formation contains vast gas reservoirs in the southwest Iran and is composed of three Members: The Lower Dalan Member is Wordian to Capitanian in age; the Nar Member is latest Capitanian and the Upper Dalan Member corresponds to Wuchiapingian to Changhsingian. Lower and Upper Dalan Members include mainly limestone, dolomite and Nar member mostly consist of anhydrite and thin interlayer of dolomite toward the base. The biostratigraphic study allows individualizing Foraminifers from the Roadian to the Changhsingian (Middle to Late Permian). Based on the stratigraphic distributions of the Biostratigraphically significant fauna and flora the following 5 biozones and age determinations are proposed in the Upper Permian Dalan Formation:

1. *Paraglobivalvulinoides septulifera zone (Changhsingian)*
2. *Paradagmarita zone (Changhsingian)*
3. *Shanita zone (Middle - Late Capitanian)*
4. *Schwagerina zone (Wordian - Middle Capitanian)*
5. *Neoendothyra zone (Roadian)*

Keywords: Microbiostratigraphy, Lithostratigraphy, Dalan, Permian, Zagros, Biozone, Formation, Southwest Iran.

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Contribution/ Originality

This study is one of very few studies which have investigated the Permian sequences of different layers in Kuh-e-Surmeh (Zagros Basin). The results of this study will help to make Paleogeographic maps, interpretation of Permian Basin, Recognition of lithology specificities and Separation and definition of the Permian sequence.

1. INTRODUCTION

Located in the middle part of the Alpine-Himalayan orogenic belt, the Zagros basin is approximately 1400 km long and 190 km wide extending NW-SE from the Taurus Mountains in NE Turkey to the Strait of Hormuz in Iran (Stocklin, 1968; Falcon, 1969; Haynes and McQuillan, 1974; Scott, 1981). The Zagros Fault Thrust Belt is divided into two tectonic zones from the NE to the SW: The Thrust zone and the Folded Zagros (Falcon, 1967;1974; Stocklin, 1968). Folded Zagros in the geological and tectonic map of Iran is subdivided into three domains: 1. Lurestan, 2. Dezful Embayment/Izeh zone/Abadan Plain and 3. Fars. (Fig.1). the study area is located in the NW part of the Fars and Bushehr provinces. This region presents a particular complexity due to the overprint of two different orogenic systems, the Late Cretaceous obduction and thrusting that affected the Northern border of the Arabian plate from Oman to Cyprus (Ricou, 1971) and the Neogene Zagros-Makran orogeny (Stocklin, 1968; Falcon, 1969; Ricou *et al*., 1977).

During the early Permian the clastic sediments of the Faraghan Formation were deposited in the Zagros basin which was succeeded by Dalan Formation consisting of limestones and dolomite and is Middle Permian and Late Permian in age. The presence of marine fossils particularly Fusulinidae family, indicate open marine conditions during its deposition (Ghazban and Motiei, 2007). The Dalan Formation together with the underlying Faraghan Formation and the overlying Kangan Formation, were placed in "the Deh Ram Group", a term introduced by Szabo and Kheradpir (1978). The Ram is a name of a place 20 km SSW of Surmeh Mountain 230 km SE of Shiraz. According to Motiei (1994), the Deh Ram Group consisting of 3 Formations namely Faraghan, Dalan and Kangan from Permian to Triass.

The presence of repeated and extensive source rock beds; excellent carbonate and some sand-stone reservoirs in good juxtaposition; efficient regional seals; huge anticline traps; continuous sedimentation and active tectonic regimes during most of the Phanerozoic make the Zagros region as one of the richest provenances in the world in terms of hydrocarbon accumulations.

The first studies on the Permian and Triassic sequences were done in 1930 by Harrison (1930) in the Zagros basin. In addition, Study of Dalan Fm. By James and Wynd (1965), Stocklin (1968), Setudehnia (1978), Szabo and Kheradpir (1978), Baghbani (1988), Beydoun (1991), can be mentioned.

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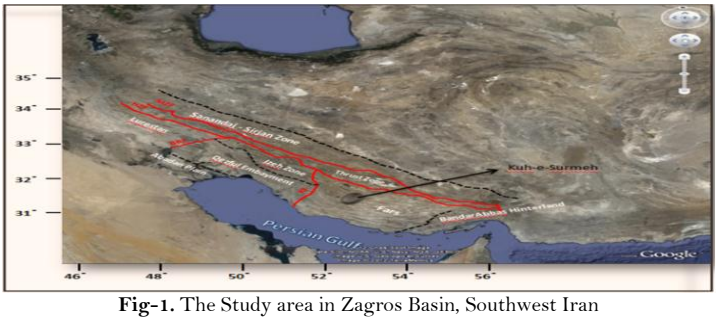

Fig-1. The Study area in Zagros Basin, Southwest Iran

1.1. Method of Study

Stratigraphically, this study is focused on the Upper Permian Dalan Formation which is equivalent to the Upper Khuff in Qatar, United Arab Emirates and Saudi Arabia (Sharland *et al.*, 2001).

Microbiostratigraphy and Lithostratigraphy of the Upper Permian Dalan Formation in the Zagros basin was carried out in several steps as follows:

1. Collection of articles, reports and maps pertaining to previous studies conducted in the study area.
2. Paleontological and petrological studies of thin sections in Kuh -e- Surmeh in order to classify the Permian Foraminifera, Biozones and Dunham classification
3. Mapped the stratigraphic column
4. Investigation and separation of Lithostratigraphic units for Permian Sequences
5. Plotting of Microfossils ranges
6. Investigation and seperation of Biostratigraphic units to determine their ages

Biostratigraphically, the results are consistent with the studies of Vachard *et al.* (2002), Jenny and Stampfli (2000) and Baghbani (1988).

2. DISCUSSION

2.1. Study Location and Geological Overview

This paper focuses on the Upper Permian Dalan Formation at Kuh -e- Surmeh in the Zagros basin which provides excellent analogues of Middle East Permian Sediments. The Kuh -e- Surmeh is located at Fars zone from Zagros basin (Fig.1). Fars zone is divided into Inner Fars and Outer Fars. The Outer Fars is subdivided into Coastal Fars and Subsoastal Fars and provides continuous sequence from the base of the Lower Dalan Member to the base of the Kangan Formation; thus the entire Dalan sequence has been studied. The Zagros fold and thrust belt was formed by collision of two tectonic plates; the Iranian and Arabian Plates. Recent GPS measurements in Iran have shown that this collision is still active and the resulting deformation is distributed non-uniformly in the country, mainly taken up in the major mountain belts like Alborz and Zagros (Nilforoushan *et al.*, 2003).

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2.2. Lithostratigraphy of Kuh -e- Surmeh

Following the Permo-Carboniferous glaciations and the Pangean assembly, the Middle Permian is marked by a global drying of climate (Angiolini *et al*., 2003). Thus the Late Palaeozoic evolved from icehouse during the Early Permian (Cisuralian) to greenhouse period during the Late Permian-Early Triassic (Kidder and Worsley, 2004). Kuh -e- Surmeh is placed in Fars zone from the Folded Zagros Belt (External Fars). In this study the Dalan Formation is about 585 m thick which overlays the clastic and shale Faraghan Formation and is Middle to Late Permian in age. Dalan Formation is divided into 3 members, Lower Dalan, Nar and Upper Dalan and from the bottom to the top (Appendix 1).

- **Lower Dalan Member from SZ101 to SZ3166.**

The Lower Dalan Member is 185 m thick and is divided into 3 beds as follows and from the base to the top:

- **BED 1**

✓ 23m, brown limestone containing Foraminifera, Echinoderm debris, Gastropod debris, Algae and Shell debris with interbeds of dolomitic limestone and dark brown dolomite.

✓ 17m, brown to dark brown limestone containing Foraminifera, Echinoderm debris, Bryozoa debris, Gastropod debris, Algae and Shell debris.

- **BED 2**

✓ 45m, brown to light gray dolomite inter-bedded with brown limestone and containing Foraminifera, Shell debris, Ooid and Pelloid.

✓ 10m, brown limestone and containing Ooid inter-bedded with brown dolomitic limestone.

✓ 27m, brown to light gray dolomite.

- **BED 3**

✓ 35m, gray to brown limestone containing Intraclast, Ooid and Pelloid inter-bedded with brown to light gray dolomite.

✓ 10m, brown to light gray dolomite inter-bedded with gray to brown limestone.

✓ 18m, gray to brown limestone containing Foraminifera, Echinoderm debris, Bryozoa debris and Ooid.

- **Nar Member from SZ3166 to AKH3243.**

The Nar Member is 210 m thick and is characterized by Mud-dominated deposits. This succession shows huge variations of facies association. The Nar Member consists in Anhydritic unit (hard to very hard anhydrite and light gray to dark brown dolomite), which could correspond to the Middle anhydrite separating the Dalan Formation into Lower and Upper Dalan Members. Generally, these facies are interpreted as deposits in semi-enclosed hyper saline depressions, in a relative sea level falling (Insalaco *et al*., 2006). However in Kuh-e-Gahkum and Kuh-e-Faraghan outcrops, the depositional environment corresponds to open-marine carbonates (Szabo and Kheradpir, 1978). Lithological succession of Nar Member is divided into 3 beds as follows and from the base to the top:

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- **BED 1**

✓ 35m, gray to brown limestone containing Foraminifera and Ooid inter-bedded with gray to brown dolomite and white anhydrite.

- **BED 2**

✓ 65m, gray to brown limestone containing Foraminifera inter-bedded with white anhydrite and gray to brown dolomite.

- **BED 3**

✓ 110m, gray to brown limestone containing Foraminifera, Echinoderm debris, Ooid and Pelloid inter-bedded with gray dolomitic limestone and white anhydrite.

- **Upper Dalan Member from AKH3243 to AKH3320.**

The Upper Dalan Member is 190 m thick and mainly is made up ooids dominated facies deposited in platform morphology which were deposited in high energy conditions. Lithological succession of Upper Dalan Member is as follows and from the base to the top:

✓ 15m, light brown limestone inter-bedded with white anhydrite and gray dolomite.

✓ 10m, light brown limestone containing Foraminifera, Echinoderm debris, Gastropod debris, Intraclast and Ooid with interbeds of gray dolomite.

✓ 15m, light brown limestone inter-bedded with gray dolomite and light brown dolomitic limestone.

✓ 20m, cream limestone containing Foraminifera, Echinoderm debris, Algae, Shell debris and Ooid.

✓ 15m, limestone containing Foraminifera, Echinoderm debris, Algae, Shell debris and Ooid.

✓ 20m, gray to brown limestone inter-bedded with argillaceous limestone, containing Foraminifera, Echinoderm debris, Ostracod debris, Algae and Shell debris.

✓ 17m, brown limestone containing Foraminifera, Pelloid and Ooid inter-bedded with brown dolomitic limestone.

✓ 8m, brown limestone containing Foraminifera, Echinoderm debris and Shell debris.

✓ 15m, brown limestone containing Foraminifera and Ooid inter-bedded with brown dolomitic limestone.

✓ 20m, brown dolomitic limestone inter-bedded with brown limestone.

✓ 10m, light gray to gray limestone containing Foraminifera, Echinoderm debris, Ostracod debris, Algae and Shell debris.

✓ 25m, light gray limestone containing Foraminifera, Echinoderm debris, Algae and Shell debris.

2.3. Microbiostratigraphy of Kuh -e- Surmeh

The main results of the Paleontological study are resumed in Appendix 1 and correspond to the biostratigraphic synthesis of the Kuh -e- Surmeh. The main Foraminifera and Non-

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Foraminifera associations are illustrated in the following plate (Plate 1). The associations are discussed in term of their occurrence and their abundance in the Kuh -e- Surmeh.

- **The Lower Dalan Member**

The Lower Dalan Member is Guadalupian in age (Wordian-Upper Capitanian stages) (Szabo and Kheradpir, 1978).

Foraminiferal assemblage described in this area and marking this period consists in a *Neoendothyra* zone. This biozone is observed in the Thrust zone and the Folded Zagros (Baghbani, 1988). For the authors the occurrence of *Neoendothyra* sp. designates the Roadian. The *Neoendothyra* zone is associated with *Palaeotextularia* sp., *Globivalvulina* sp., *Hemigordius sp*., *Pachyphloia* sp., Bryozoa debris, Gastropod debris, Echinoderm debris, Shell debris, Dasyclad algae. In Kuh -e- Surmeh the Wordian to Middle Capitanian stages include the *Schwagerina* zone which is attested by the occurrence of *Schwagerina* sp. the *Schwagerina* zone is associated with *Agathammina* sp., *Agathammina pusilla*, *Hemigordius* sp., *Nankinella* spp., *Palaeotextularia* sp., *Neoendothyra* sp., *Globivalvulina* sp., *Staffella* sp., *Sphaerulina* sp., *Pachyphloia* sp., *Geinitzina* sp., *Earlandia* sp., Echinoderm debris, Gastropod debris, Shell debris, Dasyclad algae, Mizzia sp., Intraclast, Ooid, Pelloid.

- **The Nar Member**

The Evaporitic Nar Member is Capitanian in age (Baghbani, 1988; Vachard *et al*., 2002; Insalaco *et al*., 2006). In the both Fars area and Zagros Mountains the first appearance of *Globivalvulina* can correspond to the Nar Member (Baghbani, 1988). In the Kuh -e- Surmeh, the Nar Member is characterized by one of the main appearance of *Schwagerina*. The Middle to Late Capitanian stage includes the *Shanita* zone which is attested by the occurrence of *Shanita* sp.. This zone consists in an assemblage of *Agathammina pusilla*, *Discospirella plana*, *Globivalvulina graeca*, *Hemigordius reicheli*, *Schwagerina* sp., *Globivalvulina* sp., *Hemigordius* sp., *Pachyphloia* sp., Echinoderm debris, Intraclast, Ooid, Pelloid. As reported by (Baghbani, 1988; Insalaco *et al*., 2006), the latest Capitanian is attested by the first occurrence of Shanita. In the Kuh -e- Surmeh, the typical Shanita is associated with Non-Skeletal grains including Ooids.

- **The Upper Dalan Member**

According to Szabo and Kheradpir (1978), Baghbani (1988) and Sharland *et al*. (2001), this member is Lopingian in age. In Kuh -e- Surmeh, the occurrence of *Paradagmarita* allows us to define a *Paradagmarita* zone for the Upper Dalan Member which confirm the Changhsingian age. In Kuh -e- Surmeh the Changhsingian stage includes the *Paradagmarita* zone which is attested by the occurrence of *Paradagmarita* sp.. This zone consists in an assemblage of *Nankinella* spp., *Hemigordius* sp., *Globivalvulina* sp., *Globivalvulina vanderschmitti*, *Dagmarita* sp., *Dagmarita chanakchiensis*, *Pachyphloia* sp., *Paraglobivalvulina* sp., *Paraglobivalvulina mira*, *Ichtyolaria* sp., *Ichtyolaria primitive*, *Rectostipulina* sp., Echinoderm debris, Gastropod debris, Ostracod debris, Shell debris, Mizzia sp., Ooid, Pelloid. In Fars area, it generally admits that the Changhsingian interval include a *Paradagmarita* zone (Baghbani, 1988). This genius is associated with

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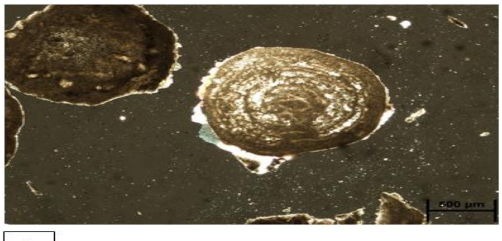
Paradagmarita monody, *Globivalvulina* sp., *Pachyphloia* sp., *Geinitzina* sp., *Staffella* sp., *Sphaerulina* sp., *Hemigordiopsis* sp., large assemblage of Hemigordius sp., Mizzia sp., Echinoderm debris and Gastropod debris. Finally, in the both Fars area and Zagros Mountains the latest Lopingian is attested by the beginning of the *Paraglobivalvulinoides septulifera*, and the first occurrence of *Paraglobivalvulinoides septulifera* (Baghbani, 1988). In Kuh -e- Surmeh the latest Lopingian includes the *Paraglobivalvulinoides septulifera* zone which is attested by the occurrence of *Paraglobivalvulinoides septulifera*. This zone consists in an assemblage of *Globivalvulina* sp., *Pachyphloia* sp., Bryozoa debris, Ostracod debris, Shell debris.

3. CONCLUSION

In Kuh -e- Surmeh, The Upper Permian Dalan Formation contains vast gas reservoirs in the southwest Iran and is composed of 1) The Lower Dalan Member corresponds to Wordian to Capitanian; 2) the Nar Member is latest Capitanian and 3) the Upper Dalan Member corresponds to Wuchiapingian to Changhsingian. Lower and Upper Dalan Members include mainly limestone, dololite, dolomitic limestone and Nar member mostly consists of anhydrite and thin interlayer of dolomite toward the base. The biostratigraphic study allows individualizing Foraminifers from the Roadian to the Changhsingian (Middle to Late Permian). Based on the stratigraphic distributions of the Biostratigraphically significant fauna and flora 5 biozones and age determinations are proposed in the Upper Permian Dalan Formation.



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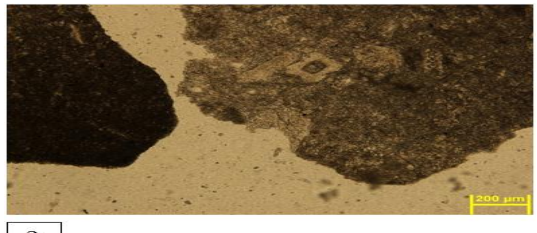

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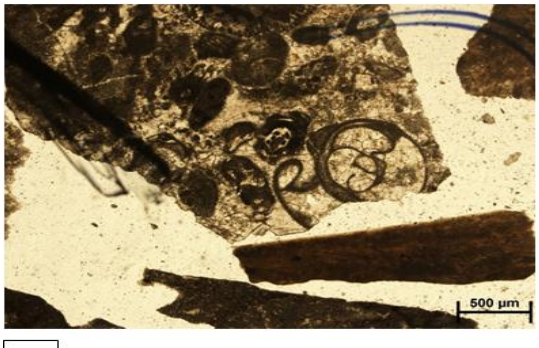

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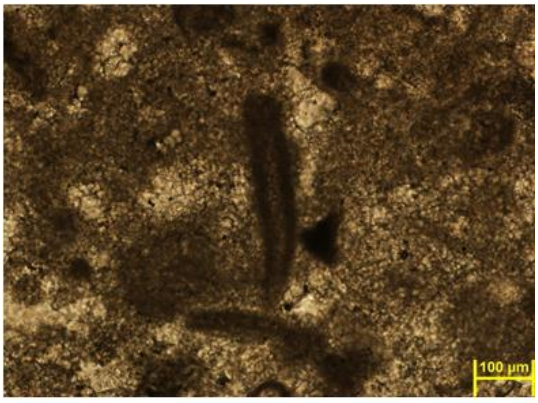

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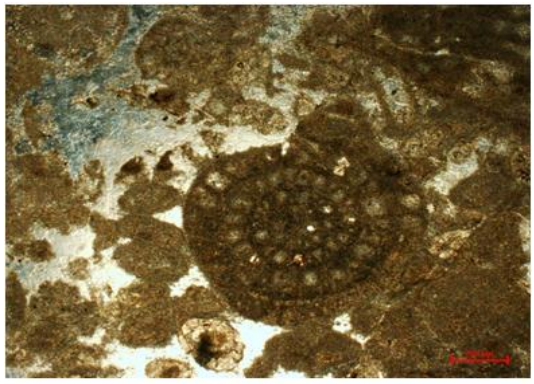

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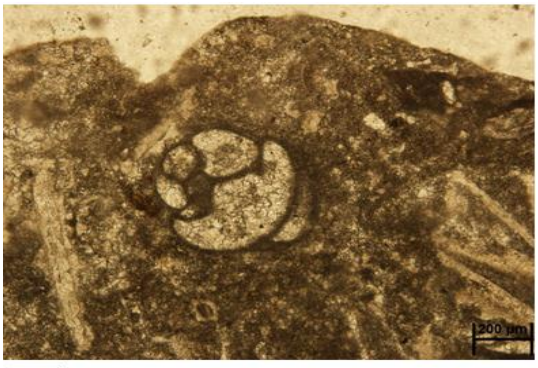

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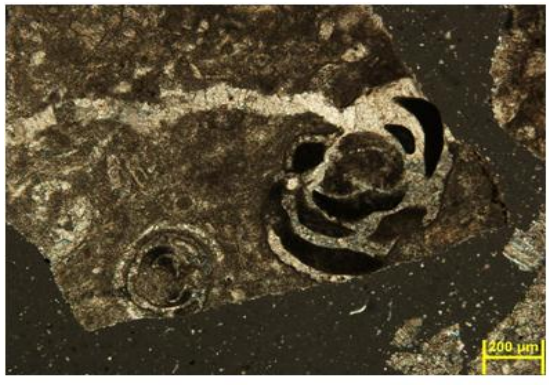

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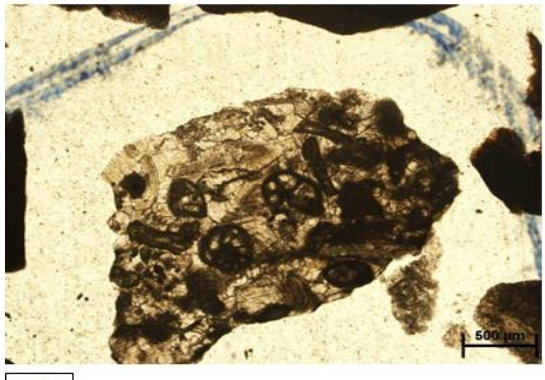

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1. *Shanita* sp.
2. *Rectostipulina* sp.
3. *Paraglobivalvulinoides septulifera*
4. *Nankinella* sp.
5. *Earlandia* sp.
6. *Eoverbeekina* sp.

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7. *Globivalvulina* sp.
8. *Hemigordius* sp.
9. *Pachyphloia* sp.
10. *Paradagmarita* sp.

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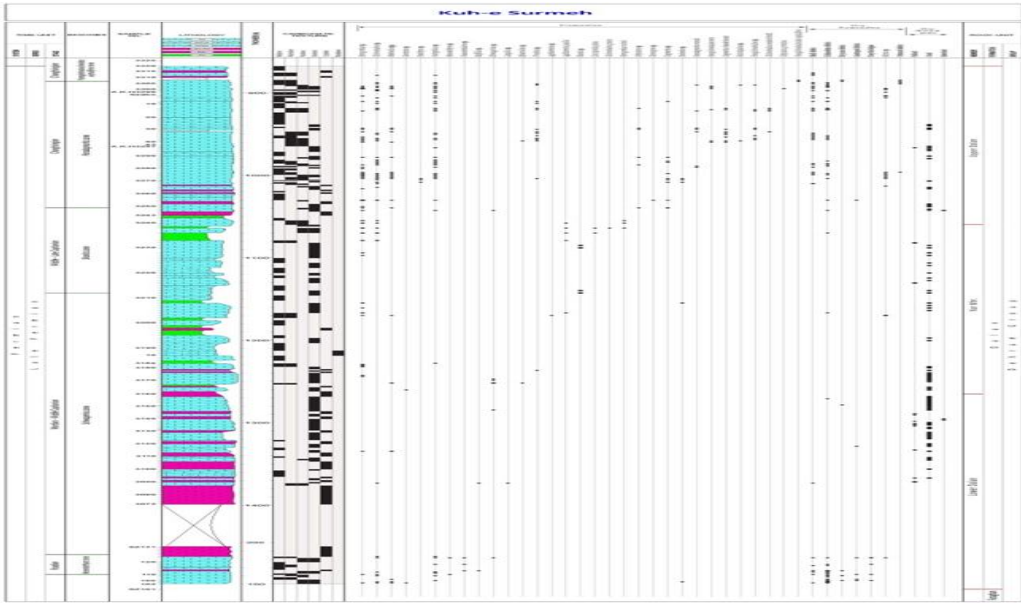

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